

STATUS OF CORAL REEFS IN THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

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Introduction

The Marianas Archipelago encompasses 15 islands and numerous banks oriented on a north-south axis stretching over 460 nmi from Santa Rosa Reef south of Guam, to Uracas Bank north of the island of Uracas, or Farallon de Pajaros. Approximately 120 nmi west of the main island chain exists a succession of seamounts also oriented on a north-south axis, referred to as the west Mariana Ridge.



Figure 277. Volcanic activity on Pagan Island (Photo: Americopters, Inc.).

The Commonwealth of the Northern Mariana Islands (CNMI) is a political subset of the Mariana Archipelago that includes Rota Island in the south, extending northward to Uracas Bank. The 14 islands of the archipelago are geologically divided into two types; the southern arc characterized as raised limestone plateaus overlying volcanic cores, and the more recent northern islands are basaltic and volcanically active.

The southern arc consists of islands and banks from Rota Island to Sonome Reef north of Farallon de Medinilla.

The oldest and most complex reefs in the CNMI are associated with the western (leeward) sides of these islands. The majority of the CNMI's residents live on three of these islands: Rota, Tinian, and the Capitol, Saipan.

The northern arc consists of all islands and banks from Esmeralda Bank to Uracas Bank north of Uracas Island. The chain of islands north of Saipan are collectively referred to by local CNMI residents as the 'Northern Islands.' The extent of reefs around these islands is unassessed, however preliminary indications are that there is less reef development in comparison to the southern islands. Although some of these islands have held small permanent and seasonal communities, all permanent residents were evacuated in 1981 after the eruption of Pagan (Fig. 277). The banks and seamounts of the western Mariana Ridge are the youngest geologically, with some of the banks rising to nearly 9 m from the surface.

There is currently no good estimate of the total area of coral reefs in the CNMI. The length of total coastline is approximately 417 km (D. Mauro, pers. comm.). Nearly all of this is potential coral habitat, although active reef development may not be occurring in all areas. This is exclusive of the numerous offshore banks and reefs within CNMI's EEZ, nor does it include the extensive coral platform adjacent to Saipan.

Condition of Coral Reefs

The local interagency Marine Monitoring Team (MMT) continues to survey reefs in the southern islands to develop a baseline assessment of reef health. While the majority of the surveyed reefs are in good condition, there are extensive areas in the populated southern islands where polluted runoff is either preventing recovery or degrading coral reefs. Coral bleaching during the summer of 2001 caused extensive shallow water coral mortality. However, areas with good water quality are already showing signs of recovery. Overfishing is a problem associated with population centers near the southern islands. The status of coral reefs in the northern islands remains unassessed.

Marine Macroalgae and Higher Plants – Over 150 species of algae in 80 genera, three seagrass species, and a species of mangrove have been



Figure 278. Coral reef located off of Saipan (Photo: Donna Turgeon).

identified from CNMI coral reef ecosystems. Documented algal species diversity continues to grow, due to an ongoing biodiversity survey being conducted by the Coastal Resources Management Office (CRMO). This project is documenting algal and plant species diversity and distributions within discrete habitats and throughout the archipelago. It is supported primarily with a NOAA Coral Reef Initiative grant.

Seagrasses are found only within the extensive Saipan Lagoon and in a small area on Rota. There have been extirpations (localized extinctions) on southern reef flats on both Rota and Saipan.

Mangrove habitat is restricted to two small areas near the commercial port areas in Saipan. Although these small areas represent the northernmost mangrove communities in the western Pacific and are unique habitat in the CNMI, they have no legal protection.

Coral Condition – There have been 256 species of corals from 56 genera and 41 octocorals in 20 genera identified from CNMI coral reef habitats (Randall, 1995, Houk, unpub. data, Starmer unpub. data). These numbers continue to grow as the MMT continues its surveys.

Diversity is higher in the southern islands where reefs are older, more developed, and have more diverse habitats. Coral density, species richness, and coral cover on Saipan reefs all tend to increase moving from the shoreline to the outer reef margin (Randall 1991, Fig. 278). Coral cover in the inner reef zone and on the reef flat of most reef areas on Saipan tends to be patchy with fewer species and less coverage than on the reef fronts and terraces (Randall 1991). This may be attributed to the low

level of water on many reef flats, resulting in high variations of temperature and salinity.

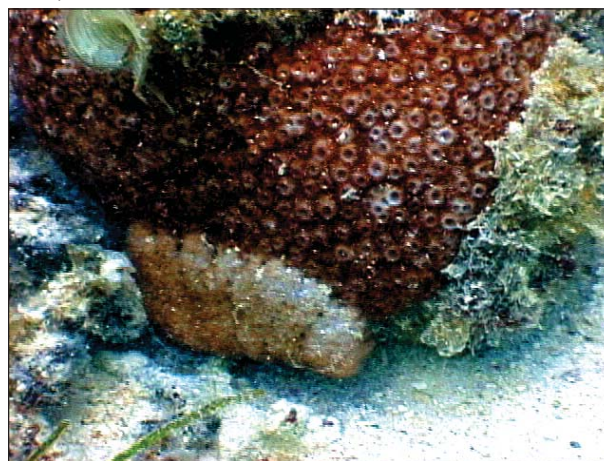
Fewer coral studies have been conducted on Tinian and Rota. However, fringing reef communities on these islands are expected to be similar to those on Saipan and Guam. Of the northern islands, detailed surveys have only been conducted for Maug (Eldredge *et al.* 1977), and indicate that coral diversity is much lower, with only 74 species of scleractinian corals and four species of non-scleractinians in localized coral communities.

The MMT is investigating disease incidences and potential impacts of three common coral reef diseases: coralline algae lethal orange disease, tumors, and black-band disease (Fig. 279).

Large Mobile Invertebrates – A marine species list was compiled for CNMI, documenting 101 crustacean species, 15 echinoderm species, 30 annelid species, and 520 molluscan species (Asakura and Furuki 1994). Two gastropods (*Echininus viviparis* and *Nerita guamensis*) are endemic to the southern Marianas and Guam (UNEP/IUCN 1988). Also, 28 species of sponges and 11 species of ascidians have been observed in the CNMI (J. Starmer pers. comm.).

At present, the U.S. Federal Aid in Sportfish Restoration program, which provides the bulk of the Division of Fish and Wildlife's (DFW) fisheries research funding, limits invertebrate research. As a result, there is only minimal data collection of both commercial and recreational/subsistence species. Only a small amount of data have been collected on the topshell gastropod, sea cucumbers, and the

Figure 279. Detail of a coral with a tumor (Photo: Peter Houk).



spiny lobster. The CRMO is currently conducting an invertebrate biodiversity survey with the MMT.

After initially publicized outbreaks in the late 1960s and early 1970s, the crown-of-thorns starfish briefly reappeared in large numbers on Saipan's reefs in 1984 (Fig. 280). Presently this starfish has been noted in low numbers on most reefs in Saipan, Tinian, and Rota. Two areas with apparently persistent populations have been identified by the MMT: the eastern side of Puntan Naftan near Boy Scout Beach on Saipan and Unai Babui on the eastern side of Tinian.

Fish and Harvested Species – The ichthyofauna of CNMI belongs to the Indo-West Pacific (Myers 1999). According to the latest information (Myers and Donaldson in press), there are 1,019 species of shorefishes (epipelagic and demersal species found to 200 m) from the islands of the Southern Marianas, making no distinction between Guam, Rota, Tinian, and Saipan. Previously, 946 species of fish had been recorded in the Mariana Islands, with 933 recorded in the southern islands and 427 species in the northern islands (Donaldson 1995).

The bulk of the fish fauna in the Marianas, as in other parts of the region, is comprised of the ten largest fish families: Gobiidae, Labridae, Serranidae, Pomacentridae, Muraenidae, Apogonidae, Blennidae, Carangidae, Acanthuridae, and Chaetodontidae (Moots *et al.* 2000). Only three species of shallow-water reef fish are known to be endemic to the Mariana Islands: the yellow-crowned butterflyfish (*Chaetodon flavocoronatus*, Fig. 281) and two species of Guam reef damselfish (*Pomachromis gumaensis*, *Prealticus poptae*; M. Trianni pers. comm.).

There is little data assessing the health of fish resources in the CNMI. The fish resources in the northern islands are perceived as healthier than the populated islands southern because they have the least amount of fishing pressure. An analysis of data from 1992-1993 showed that fish caught by SCUBA and spearfishing around Saipan were generally smaller than those from Tinian and catch-per-unit-effort for Saipan was lower compared to



Figure 280. Crown-of-thorns starfish (Photo: James McVey).

that for similar habitats off Tinian (Graham 1994, Trianni 1998). Trianni's analysis included Graham's 1992-1993 data, data from 1995-1996 collected from the same the SCUBA spearfishery around Saipan and Tinian, and 1995 data from a SCUBA spearfishery in the Northern Islands (Anatahan, Maug, Pagan, and Sarigan). Trianni's analysis agreed with Graham's and confirmed that the fish populations in the southern islands are impacted by fishing pressure.



Figure 281. The yellow-crowned butterflyfish is endemic to the Marianas Archipelago (Photo: Richard Pyle, FishBase).

within CNMI has been in effect since 1983, but was lifted for commercial fishing from October through December 1997. An 'open season' was declared, requiring a basal diameter minimum of 3 inches as per DFW regulations. Nearly 4 mt of topshell were harvested during that open season. About 0.36 mt of topshell (over 1,000 animals) harvested at the beginning of the period were sampled by DFW Conservation Officers. About 3% were found to be undersized and subsequently returned to the reef (Trianni 2002).

In 1993, along with the South Pacific Commission, the DFW conducted an assessment of the potential for a commercial or recreational/subsistence fishery for this gastropod. The assessment concluded that densities in the CNMI would not be able to

The topshell gastropod is an introduced species in the Marianas. Imported in 1938 by the Japanese South Seas Government (Asano 1938, Adams *et al.* 1994), it was seeded on Saipan, and then introduced from Saipan to Tinian, Rota, Guam, and Agrihan. Commercially-harvested in other parts of Micronesia, its shell is used for buttons, and the meat is a popular food source of the local CNMI population. A moratorium protecting topshell from exploitation

support a sustained fishery (Adams *et al.* 1994). The moratorium protecting topshell has now been extended for an indefinite time period.

In 1996, the CRMO contracted the DFW to evaluate the populations of nine species of edible sea cucumbers in the Saipan Lagoon (Fig. 282). That survey concluded that populations were too low to support commercial fishing (Tsuda 1997), but might be able to sustain a recreational/subsistence fishery.

Commercial harvesting of sea cucumbers took place on Rota from October 1995 through May 1996 (Trianni 2002), and on Saipan from July 1996 through December 1996. Data collected by the Division and Wildlife for the period from Saipan showed a decline in commercial landings of sea cucumbers, which was corroborated by a DFW post-harvest survey (Trianni 2002).

Marine Reptiles and Mammals – Green and hawksbill sea turtles are known to frequent near-shore waters in the CNMI (Fig. 283). A year-long study conducted on Tinian suggested that resident subadult and nesting adult green turtles might belong to separate populations due to distinct size differences between the two (Pultz *et al.* 1999). The study also indicated that nearly all of Tinian's beaches are potential nesting areas. The same authors also expressed concern over not seeing any hawksbills during the 13-month study (Pultz *et al.* 1999). There is not enough information about habitat use, population dynamics, or genetic structure to summarize status of sea turtles throughout the CNMI.

According to G. Paulay (pers. comm.), there are anecdotal accounts of the viviparous yellowbellied sea snake (*Pelamis platurus*) from the CNMI. This species is pelagic and ranges from East Africa to the Pacific coast of the Americas (Allen and Steene 1996).

Marine mammals verified to frequent CNMI coastal areas residually, seasonally, or during migration include spinner, striped, and bottlenose



Figure 282. Two species of sea cucumbers found in the Mariana Archipelago (Photo: Gustav Paulay).

dolphins (*Stenella longirostris*, *S. coeruleoalba* and *Tursiops truncatus*), and numerous whale species. These include pygmy and dwarf sperm whales (*Kogia simus* and *K. breviceps*), pilot whales (*Globicephala macro-rhynchus* or *G. mala*), sperm whales (*Physeter catadon*), false killer whales (*Pseudorca crassidens*), humpback whales (*Megaptera novaeangliae*) and Bryde's whales (*Balaenoptera edeni*) (Trianni pers. comm.). Other circumtropical species most likely traverse CNMI's exclusive economic zone. The spinner dolphin is the most observed cetacean in CNMI (Fig.

284), having been sighted at various islands and banks, in addition to recent stranding episodes in Saipan Lagoon (Trianni and Kessler in press).

Water Quality – Both point and nonpoint sources of pollutants are responsible for lowering the quality of CNMI's coastal water. Sewage outfalls, sewage overflows, dredging, and sedimentation from unpaved roads and development are significant factors degrading marine water quality. Eutrophication and sedimentation are the two biggest stressors.

All three southern islands have unpaved secondary roads that funnel soil and sediment into nearshore waters during heavy rains, increasing turbidity of nearshore waters. There have been several reports of sedimentation associated with major construction projects (e.g., the Nikko Hotel, Lau Lau Bay Resort, and Bird Island Road) that covered near-

Figure 283. Resident sea turtle (Photo: CNMI Division of Fish and Wildlife).





Figure 284. Spinner dolphins (Photo: Donna Turgeon).

shore corals. On several of the northern islands deforestation by feral animals is causing nearshore sedimentation. (T. de Cruz pers. comm.)

Farallon de Medinilla has been leased by the Navy since 1981 as a bombing target. No quantitative studies have been conducted to determine whether bombing has increased sediment runoff from the island. Little quantitative data on sedimentation have been collected and the impact of sediment on coral reefs has not been well documented.

Nutrient loading is also a concern for the reefs adjacent to populated islands. Potential sources of nutrients on the developed islands are septic systems and sewage outfalls, fertilizer on golf courses and agricultural land, and animal wastes. This includes wastes from introduced animals (e.g., Pagan has high populations of cows and pigs; other islands have goats). The impact of these on marine water quality in general, and coral reef resources in particular, is not well known.

The Division of Environmental Quality (DEQ) Surveillance Laboratory currently monitors salinity, dissolved oxygen, temperature, pH, turbidity, and fecal coliform. These parameters are monitored weekly for Saipan West Beaches, and monthly for Tinian, Rota, and Managaha Beaches. Saipan East Beaches are monitored quarterly (Houk 2002).

The CNMI Water Quality Standards were largely based on the review of existing water quality standards for other tropical islands. Due to the potential impact and

delicate aspects of the coral reef eco-systems and the lack of existing data, stringent nutrient standards were adopted for the CNMI (Houk 2002). The DEQ Laboratory recently began collecting data on nutrient levels. There is concern whether the current readings of nutrients reflect natural or anthropogenic sources (Houk 2002). A final determination will require monitoring nutrient levels in marine waters surrounding uninhabited islands over a sufficient period of time to establish the natural ambient conditions.

Coastal Populations and Reef Economics

Prior to receiving U.S. Commonwealth status in 1978, CNMI was part of the Pacific Trust Territories under the administration of the United States, along with the Marshall Islands, Palau, and the Federated States of Micronesia. During the U.S. administration of the islands, economic development was limited, there were few commercial enterprises, and the population relied primarily on subsistence agriculture and fisheries, and Federal aid.

The population in the islands has increased 57.2% over the past ten years to 69,200 in 2000 (U.S. Bureau of Census 2002). In 1995, about 90% of the CNMI population was in Saipan, 6% was in Rota, 5% was in Tinian, and less than 1% was in the Northern Islands (Stewart 1997).

As with most tropical islands, marine-related tourism is an important part of the island economy (Fig. 285). In the early 1980s, Japan invested heavily in tourism development, bringing in large numbers of foreign workers for facility construction and operation (Stewart 1992), creating a period of dramatic economic growth. In 1996, the CNMI received 737,000 visitors who spent over \$587 million (Stewart 1997).

Commercial fish landings generate around \$1 million annually (NMFS 2001). In addition to invoice data presented in Western Pacific Regional Fisheries Management Council Plan Teams, numerous DFW Technical Reports have been published over the past eight years specifically addressing fishery resources based on data collection programs.

Figure 285. Marine-based tourism at Micro Beach, Saipan (Photo: Bill Bezzant).



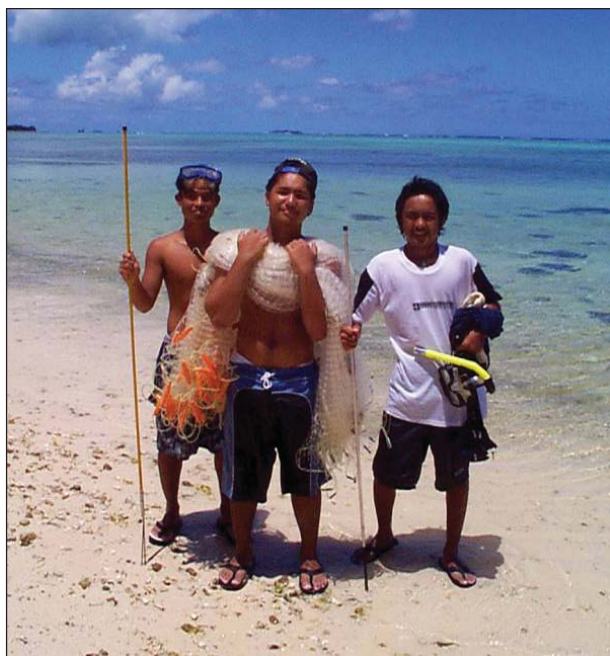


Figure 286. Young spearfishermen with their gear at Pau Pau Beach, Saipan (Photo: Bill Bezzant).

Environmental Pressures on Coral Reefs

Human Stresses – The nearshore reefs closest to the population centers on Saipan, Tinian, and Rota, as well as reefs surrounding Farallon de Medinilla and offshore banks used for fishing have the greatest potential to be impacted by human activities. The reefs adjacent to these southern populated islands are of great concern. They receive most of the human impact from coastal development, population growth, fishing, and tourism.

Tourism and Marine Recreation – Concerns over the potential impacts of marine recreational sports on the nearshore marine environment caused the CRMO to limit the number of permitted motorized marine sports concessions. CRMO is currently conducting a study to determine the types and extent of impacts being caused by the various marine sports so they can better manage the industry. Working with the local dive operators association, CRMO is also installing and refurbishing mooring buoys at heavily used dive sites with funds made available through the NOAA Coral Reef Initiative.

Fishing Impacts – The types of fishing and related impacts have been historically varied and continue to change as technology and the islands' demographics change (Fig. 286). The reef-associated fisheries resources that have been studied have shown impacts from commercial fishery activities. Evaluation of CNMI-wide fisheries pressures is

complicated by the lack of staff, funding, and complexity of fishery target species and age classes as a result of a growing and diverse contract worker population.

Destructive fishing methods continue to be used. They are difficult to regulate due to lack of staff and funding for enforcement agencies. Though dynamite fishing using the remains of WWII ordnance was prevalent in the past, this practice appears to be nonexistent today. While fishing using poisons (e.g., household bleach) does occur, how common the practice is or the extent of damage caused by poisons has not been documented.

Oil Spills and Ship Groundings – More than 20 vessels have grounded in the CNMI over the past several decades. The majority of these groundings were typhoon related; two were the result of operator error. While some of these vessels have since been removed, nearly half remain in the water. Although most of these vessels were reportedly cleaned of fuel and oil, they still pose a threat to coral reef habitat as they disintegrate and the debris shifts across reefs during storms.

The CRMO recently held an interagency meeting in an attempt to address vessel-grounding issues with a focus on prevention. The office intends to coordinate the development of a Vessel Grounding Action Plan that will guide CNMI officials in closing communication gaps, creating or revising laws and regulations, strengthening enforcement, developing preventive measures, and addressing funding and resources limitations (B. Lizama pers. comm.).

Other Physical Damage to Coral Reefs – The CNMI was a major battlefield during WWII, and there is a significant amount of war debris and unexploded ordnance in the nearshore waters (Fig. 287).

In 1996, through the former CNMI Governor, the former Director of the CNMI Emergency Management Office requested the U.S. Navy detonate depth charges on the wreck of a WWII subchaser at the popular Coral Gardens dive site. They felt the charges posed a hazard to recreational divers and fishermen (Worthington and Michael 1996). In response, an assessment of the administrative record of unexploded ordnance operations was conducted on Rota by the U.S. Navy and the CNMI Emergency Management Office. The force of the

detonation caused significant damage to the nearby Sasanhaya Fish Reserve, one of CNMI's few marine reserves, killing numerous fish, decimating coral, and killing an endangered hawksbill turtle (Trianni 1998). In addition, secondary damage was caused by an extensive sediment plume resulting from the blast, blanketing a large area in and around the Coral Garden site. Two typhoons subsequently caused tertiary damage and expanded the impacted area to approximately 29,000 m² (Richmond 1998). Estimates based on a value of \$2,833/m² put the total economic impact at \$82 million (J. Starmer pers. comm.).

Since World War II, the uninhabited island of Farallon de Medinilla (FDM) has been under the control of the U.S. Navy, and since 1971 has been the target site of live-fire military exercises. In 1981 the Navy signed a 50-year lease with an option to renew after 50 years, to use FDM for live-fire exercises.

In developing an environmental impact statement for military activities in the Marianas, the Navy conducted a preliminary survey of the nearshore marine resources in 1997. In the completed Environmental Impact Statement the Navy agreed to conduct an annual nearshore marine survey of FDM for three consecutive years (1999-2001). This survey collected qualitative data on fish abundance and species richness as well as coral species richness, in addition to documenting habitat changes from military exercises. Although the third year of the survey concluded in 2001, the Navy has

agreed to continue the survey as long as live-fire exercises continue.

The FDM survey team has included a U.S. Navy Contractor, and representatives from the NMFS, USFWS, and CNMI DFW. The survey team has been composed of the same individuals for both the preliminary and three-year annual survey (1997 and 1999-2001).

As in the 1997, 1999, and 2000 surveys, results of underwater surveys off Farallon de Medinilla in 2001 revealed no quantifiable impacts to marine communities from exploded ordnance, with the exception of an observation of damage to a single coral colony from the attachment wires of a fabric retardant (Belt Collins Hawaii 2001). Few fragments of exploded ordnance were noted on the reef surface.

In the areas where explosive impact may have resulted in accumulations of underwater rockslides in 1999, the habitat was not altered in a fashion to disturb existing biotic communities. In fact, the new habitat created by the rockslides provides more suitable habitat for fish and invertebrates than the adjacent unaltered area. The impact of sedimentation from accelerated erosion of the island has not been determined.

The Navy also leases approximately two-thirds of the northern portion of Tinian for training exercises and maneuvers. Results of qualitative surveys reveal very little damage to the reef structure there. In a recent environmental impact statement, the

Navy had proposed landing amphibious assault vehicles across the reef at Unai Babui. After concerns were raised by both the DFW and the DEQ, this proposal was withdrawn.

However, the CNMI did agree to allow the Navy to land air-cushioned craft over the reef if pre- and post-landing surveys indicated little damage would result. Staff from DFW participated in these surveys of Unai Chulu for the air-cushioned landing-craft exercises, and found very little damage to the reef. In general, military activities on Tinian have been conducted with a high level of sensitivity to the potential impact on the environment. However, because of

Figure 287. Military relics from World War II abound throughout CNMI both on the land and in the water (Photo: Donna Turgeon).



the large number of personnel and equipment involved in some of the Navy's exercises, the CNMI should continue to monitor these activities.

Natural Stresses –

Typhoons are a routine part of the annual seasonal cycles in the CNMI. These storms can affect coral reefs even when they do not pass directly over an island. Swells can cause coral damage through increased wave action directly and by shifting loose objects (coral, debris, grounded vessels, etc.) around the reef. The precipitation associated with typhoons also tends to increase sedimentation and nutrient inputs from polluted runoff.

Climate Change and Coral Bleaching – Bleaching was noted around Saipan in 1994, 1995, and near both Saipan and Pagan in 1997. There was no quantitative assessment of bleaching for any of these events. Over the summer of 2001, most shallow-water reefs (less than 3 m) on Saipan, Rota, and Tinian were affected by coral bleaching; bleaching was noted as deep as 18 m. Many encrusting *Montipora* and *Acropora* coral colonies died during this event. The MMT is currently collecting data to assess the effects of this bleaching event on CNMI reefs.

Current Conservation Management

Mapping – The first habitat and reef map for the CNMI was developed by the USGS for Saipan (Cloud 1959). These maps are still useful for ecological comparisons.

A beach and reef atlas was commissioned by the CRMO in 1980 (Eldredge and Randall 1980). It provided information on reef location and some information regarding habitat types for Saipan,



Figure 288. Aerial photograph of Saipan Lagoon with an overlay of habitats delineated during the Saipan Lagoon Habitat Assessment Project (Photo: CNMI Marine Monitoring Team).

Tinian, Rota, Aguijan, and Farallon de Mendinilla based on aerial photographs.

The MMT's Saipan Lagoon Habitat Assessment Project is currently mapping coral reefs and associated habitats within Saipan's western lagoon. Field surveys are verifying habitats in aerial photographs (Fig. 288). This will allow comparisons among historical aerial photography to detect ecological changes.

Expanding on this project, CRMO is now working with georectified IKONOS satellite imagery provided through NOAA to create initial coral reef maps for the

entire CNMI. The MMT is ground-truthing reef habitats in the southern islands for this mapping initiative. The MMT will collaborate with NOAA Coral Reef Ecosystem Monitoring Program to ground-truth the northern islands imagery in 2003.

Monitoring – CNMI DEQ has been testing water quality at a number of sites adjacent to population centers on Saipan since 1980. More recently, water quality testing has been extended to Tinian and

Figure 289. Diver measuring the size of a reef fish during a monitoring survey (Photo: Fran Castro).



Rota. DEQ posts warnings at local beaches when water quality parameters exceed the acceptable limits for public health.

The CNMI also collects data on coral bleaching mortalities. The Fisheries Section of the DFW has been collecting data on fish diversity and abundance primarily within the existing and proposed conservation areas on Saipan, Tinian, and Rota since 1999 (Fig. 289). During fish surveys, data are also collected on reef topography (vertical relief) and estimated hard coral cover.

There are three major monitoring activities carried out in the CNMI. First, site surveys are conducted to satisfy local and regional requirements in EIS work. These surveys provide snapshots of CNMI reefs and can be very informative, but are usually limited to a single reef area. These have been and should continue to be used to understand changes over time. For example, comparison between two sites in Lau Lau Bay (Fig. 290) that were surveyed in 1991 and recently re-surveyed in 2001 by the MMT (Houk 2001) to see how they differ.

Turf algae dominate the benthic cover (46.7% and 52.3% ten years later). Coral cover was 28.1% then and 42.0% now. The second site showed a long-term decrease in mean coral diameter and the relative frequencies of large branching corals, attributed to the 1983 crown-of-thorns starfish outbreak. Between 1991-2001, the abundance of macroinvertebrates such as sea urchins and sea cucumbers decreased at both sites (Houk 2001).

Second, the DFW is monitoring several MPAs on Saipan (Mañagaha Marine Conservation Area, Bird Island Sanctuary, and Forbidden island Sanctuary) and Rota (Sasanhaya Bay Fish Reserve), as well as the proposed Tinian Marine Sanctuary located to the north of Puntan Diablo on Tinian. Done twice a year, the surveys gather data on the diversity and abundance of fish and commercially-important invertebrates and benthic cover.

Third, the MMT surveys benthic cover, coral communities, invertebrate and fish abundance, and much more as part of its long-term marine monitoring program. These data are being incorporated into a GIS for local and federal agencies. The MMT is also monitoring a portion of Saipan lagoon and creating habitat maps. This includes benthic coverage, invertebrate abundance, biodiversity and water quality.



Figure 290. The marine ecosystem within Lau Lau Bay has been surveyed in 1991 and 2001 (Photo: Fran Castro).

With NOAA grant support, the CNMI increased local capacity to conduct long-term monitoring by hiring a manager to coordinate its coral reef program. Now the MMT monitors 13 sites off Saipan Island, 8 sites off Rota, 7 sites off Tinian, and 1 site off Aguijan. Parameters monitored include benthic coverage, coral communities, coral biodiversity, fish and macroinvertebrate abundance and diversity, sedimentation rates, and water quality. This program will provide the CNMI with a comprehensive baseline survey and the ability to track and predict changes in coral reef ecosystem health through time.

MPAs and No-take Reserves – The CNMI has eight MPAs protecting an area of 12.32 km². Of these, the Sasanhaya Bay Fish Reserve in Rota, the Mañagaha Marine Conservation Area (Fig. 291), Forbidden Island Sanctuary, and Bird Island Sanctuary are established no-take zones for all marine resources by CNMI Public Law. In addition,

Figure 291. Mañagaha Marine Conservation Area (Photo: Marianas Visitors Authority).



tion, permanent Topshell Gastropod Reserves exist on a mile-long stretch of the Saipan Lagoon barrier reef, the Lighthouse Reserve, and at Tank Beach. The Tank Beach Reserve overlaps with the Forbidden Island Sanctuary. Permanent Sea Cucumber Reserves have been established by DFW regulation at Lau Lau Bay and Bird Island, the latter of which overlaps with the Bird Island Sanctuary. A ten-year moratorium on the harvest of sea cucumbers and seaweeds was established by Public Law in 1998. The total area covered by no-take reserves is estimated at 9.63 km².

All these MPAs are monitored and regulated by the DFW, with assistance from CRMO and DEQ. Regulations for the Mañagaha Marine Conservation Area are currently in the final draft stage, and expected to be released for public review by mid-summer.

In 1998, the Tinian Delegation to the CNMI Legislature proposed creating a marine protected area along approximately one-third of the western shoreline of Tinian. Within this conservation area, the collection of any marine resources would be limited to seasonal runs of nearshore fish species including atulai (*Selar crumenophthalmus*) and juvenile goatfish (Mullidae). The legislation establishing this conservation has been sent to the CNMI Legislature for action in 2002.

A major impediment in protecting these areas is the lack of funding for enforcement. Most funding

comes from local appropriations. These have not been sufficient to provide the DFW's officers with vessels and needed enforcement equipment. Currently NOAA Coral Reef Initiative funds from 2000 have been earmarked to support the DFW Conservation Officer Section through the purchase of a vessel to be used for law enforcement purposes.

Government Policies, Laws, and Legislation

Legislation is in place for water-quality standards, land-use regulations, waste disposal, fishery management, habitat protection, endangered species, protected areas, ship pollution, and other environmental issues. Enforcement of these regulations is hampered by a lack of funding and resources.

Funding to support MPA regulation development and enforcement was recently provided to the DFW through a NOAA Coral Reef Initiative grant. CRMO is also working with an interagency group to refine or create legislation that will allow improved local management of vessel grounding issues as part of the CNMI Coral Reef Program. Local resource management agencies are emphasizing education to increase understanding of and concern for the environment and, hopefully, increase voluntary compliance with regulations.